MO 18: Cold Molecules and Cold Chemistry (joint session MO/Q)

Time: Wednesday 14:30–16:30 Location: HS XVI

Invited Talk MO 18.1 Wed 14:30 HS XVI

Cold and Controlled Reactive Collisions — •Jolijn Onvlee — Institute for Molecules and Materials, Radboud University, Nijmegen, The Netherlands

What exactly happens during a chemical reaction? Our aim is to investigate fundamental chemical reactions and their underlying dynamics at the full quantum level. To achieve this, we let individual molecules and atoms collide and react with each other in a crossed molecular beam machine.

We can precisely control the velocity and quantum state of a paramagnetic reactant before the collision by using a Zeeman decelerator. After the collision, we accurately probe the reaction products and their velocity vectors using laser-based techniques and velocity map imaging. This powerful combination of techniques allows for scattering experiments with extraordinary resolution.

Here, I will show how we use this approach to investigate the prototypical insertion reaction between excited sulfur atoms and hydrogen molecules in high detail and in unexplored energy regimes. With these experiments, we aim to provide a sensitive test for potential energy surfaces and scattering calculations used to describe the molecular reaction dynamics in this system. This will enable us to deepen our understanding of the intricate dynamics underlying a reaction.

MO 18.2 Wed 15:00 HS XVI

Low-energy collisions between two indistinguishable tritium-bearing hydrogen molecules: HT+HT and DT+DT — •Renat Sultanov — The University of Texas Permian Basin, Odessa, Texas, USA

Elastic and rotational energy transfer collisions between two tritium-containing hydrogen molecules are computed at low- and very low energies, down to ultra-cold temperatures: $T \simeq 10^{-8}$ K. A pure quantum-mechanical approach is applied. A high-quality global six-dimensional potential energy surface (PES) has been appropriately modified and used in these calculations. In the case of the symmetrical $H_2 + H_2$ or $D_2 + D_2$ collisions one can use the original H_4 PES as it is, i.e. without transformations. However, in the case of the non-symmetrical (or symmetry-broken) $HD + H_2/D_2$, $HT + HT$, $DT + DT$ scattering systems one should also apply the original H_4 potential (PES), but propagation (solution) of the Schrödinger equation runs (in this case) over the corrected Jacobi vector [1,2]. Elastic and state-selected inelastic cross sections and corresponding thermal rate coefficients will be presented.

1. R. A. Sultanov, D. Guster, S. K. Adhikari, Phys. Rev. A 85, 052702 (2012).

2. R. A. Sultanov, D. Guster, S. K. Adhikari, J. Phys. B 49 (2016) 015203.

MO 18.3 Wed 15:15 HS XVI

Dual-color microwave-dressing for collisional control in molecular dipolar Fermi gases — •Sebastian Eppelt[1,2], Shrestha Biswas[1,2], Christine Frank[1,2], Xing-Yan Chen[4], Weikun Tian[1,2], Immanuel Bloch[1,2,3], and Xin-Yu Luo[1,2] — [1]Max-Planck-Institute of Quantum Optics — [2]Munich Center for Quantum Science and Technology — [3]Ludwig-Maximilans-Universität — [4]Princeton University

Ultracold polar molecules are a promising platform for the exploration of exotic quantum matter, including topological dipolar p-wave superfluids, thanks to their long-range dipolar interactions. In this talk, we will present our work on microwave-dressing of fermionic $^{23}Na^{40}K$ molecules. Using a single, circularly-polarized, blue-detuned microwave field we can engineer intermolecular potential, where inelastic and elastic scattering tuneable via field-linked scattering resonance. This resonance is universal for systems with dipolar interactions and arises due to existence of a stable tetratomic bound state which we recently observed and characterized in our experiment. Adding a second, linearly polarized microwave field at a different frequency enables control of the long-range dipolar interaction by tuning the dipole-dipole scattering length. This improves our toolbox for creating ultracold, deeply-degenerate samples of dipolar fermionic molecules, necessary in our quest towards realizing a dipolar p-wave superfluid and beneficial for quantum simulations in optical lattices.

MO 18.4 Wed 15:30 HS XVI

Photoassociation Spectroscopy of RbYb near the Yb intercombination line — •Arne Kallweit — Uni Düsseldorf

Ultracold dipolar molecules constitute a promising system for the investigation of topics like ultracold chemistry, novel interactions in quantum gases, precision measurements and quantum information. Here we report on first experiments in our apparatus for the production of ultracold RbYb molecules. This setup constitutes an improvement of our old apparatus, where the interactions in RbYb and possible routes to molecule production have already been studied extensively. In the new setup a major goal is the efficient production of ground state RbYb molecules. We employ optical tweezers to transport individually cooled samples of Rb and Yb from their separate production chambers to a dedicated science chamber. Here we start to study interspecies interactions of different isotopes by overlapping crossed optical dipole traps. To explore the pathways towards ground state molecules we start with photoassociation spectroscopy near the intercombination line of Yb.

MO 18.5 Wed 15:45 HS XVI

Delta-Kick Collimation of Heteronuclear Feshbach Molecules — •Timothé Estrampes[1,2], Jose P. D'Incao[3,4], Jason. R. Williams[5], Éric Charron[2], and Naceur Gaaloul[1] — [1]Leibniz University Hannover, Institut für Quantenoptik, Germany — [2]Université Paris-Saclay, CNRS, Institut des Sciences Moléculaires d'Orsay, France — [3]JILA, NIST, and the Department of Physics,University of Colorado, Boulder, CO 80309, USA — [4]Department of Physics, University of Massachusetts Boston, Boston, MA 02125, USA — [5]Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA, USA

Delta-Kick Collimation [Phys. Rev. Lett. 78, 2088 (1997)] is a well-known process in atomic physics that allows to drastically reduce the expansion energy of a cold sample by flashing an external potential during its release. Here, we theoretically explore the extension of this process to cold heteronuclear Feshbach molecules.

We first investigate the validity of neglecting the coupling between the center-of-mass motion and molecular vibrations. After establishing the domain of validity for this approximation, we use scaling approaches to estimate the achievable gains over a large range of temperature and density regimes. For typical external trap paramaters, the expansion energy of a thermal cloud could be reduced by a factor of 100, increasing to over 500 for a heteronuclear condensed molecule.

MO 18.6 Wed 16:00 HS XVI

Laser cooling of barium monofluoride molecules — •Marian Rockenhäuser[1], Felix Kogel[2], Tatsam Garg[1], Jakob Weiss[1] und Tim Langen[1] — [1]TU Wien, Atominstitut, Cold Molecules and Quantum Technologies — [2]Universität Stuttgart, 5. Physikalisches Institut

Barium monofluoride (BaF) molecules are sensitive probes for precision tests of fundamental symmetries. However, due to the high mass, comparatively narrow linewidth, resolved hyperfine structure, and potential branching losses through an intermediate electronic state, this molecular species is notoriously difficult to cool. We will report on the observation of Sisyphus-type forces in transversal cooling of 138BaF and the less abundant bosonic isotopologue 136BaF realizing the first isotopologue-selective laser cooling of molecules. Furthermore, we will discuss our progress towards cooling of the fermionic isotopologue 137BaF which involves optical cycling in a 112 level system. Our results are an important step towards using intense beams of barium monofluoride for precision measurement applications, including searches for the electron's electric dipole moment and nuclear anapole moments. We also expect the results to be useful for cooling other molecular species with complex level structure.

MO 18.7 Wed 16:15 HS XVI

High-flux cold lithium-6 and rubidium-87 atoms from compact two-dimensional magneto-optical trap — •Anwei Zhu[1,2], Yunxuan Lu[1,2], Xinyi Huang[1,2], Chenhao Ni[1,2], and Xinyu Luo[1,3] — [1]Max Planck Institute of Quantum Optics — [2]Ludwig Maximilian University of Munich — [3]Munich Center for Quantum Science and Technology

We report the development of a compact setup for producing Fermi gas of ultracold ^{6}Li^{87}Rb molecules, which integrates two 2D magneto-optical traps in series for each species with a short-distance lithium Zeeman slower. The Zeeman slower enhances the lithium flux by a factor of 50, achieving a high flux of 1×10^{10} atoms/s at a moderate oven temperature of 370 degrees. In addition, the rubidium flux reaches a value of 6×10^8 atoms/s. This advancement paves the way for the rapid production of double-degenerate lithium-rubidium atomic mixtures and large samples of ultracold ground-state fermionic lithium-rubidium molecules, providing a robust platform for investigating dipolar interaction and phase transition in ultracold regime.